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# The Great Dismal Swamp National Wildlife Refuge Contaminants Monitoring Plan

Virginia Field Office
U.S. Fish and Wildlife Service

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# The Great Dismal Swamp National Wildlife Refuge Contaminants Monitoring Plan

U.S. Fish and Wildlife Service

Virginia Field Office

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## Abstract

**Title: The Great Dismal Swamp National Wildlife Refuge Contaminants Monitoring Plan.**

Abstract: Alternatives for an environmental contaminants monitoring plan have been developed for the Great Dismal Swamp National Wildlife Refuge (Refuge). This study identified sites that may be responsible for contaminant loads, determined which contaminants were at levels that would pose a concern, determined effects of water flow and land use patterns upon contaminant mobilization, identified target organisms and determined organizational resources. This information was then integrated and five alternative monitoring plans were proposed. A baseline survey for contaminants in the Great Dismal Swamp National Wildlife Refuge was recommended. Given the land use patterns and contaminants of concern, a baseline survey followed by storm water monitoring was suggested as an appropriate option for long-term contaminant monitoring. However considering the costs involved the in conducting this type of study, additional information is needed to provide documentation of contaminant inputs in the Refuge before such a study is initiated. Therefore, a final recommendation to conduct a basic hydrogeologic survey of the Refuge is presented. A hydrogeologic survey would provide the necessary information in regard to flow patterns and discharge patterns that are needed to assess the contaminant impacts previously identified.

Keywords: Environmental Contamination, Organochlorine, Pesticides, Metals, Superfund, Great Dismal Swamp National Wildlife Refuge, Dismal Swamp southeastern shrew (*Sorex longirostris fisheri*), Virginia.

## EXECUTIVE SUMMARY


The Great Dismal Swamp National Wildlife Refuge is located in southeastern Virginia and northeastern North Carolina. The Refuge is bordered by a Superfund Site, several automobile junkyards, several major highways, and agricultural fields. Several contaminant surveys have been conducted in the past, although none have been sufficiently comprehensive to make conclusive determinations of the fate of contaminants in the Refuge and its surrounding area.

From these previous studies it appears that mercury is a potential contaminant threat to top predatory fish of the Great Dismal Swamp. In addition, copper, arsenic, zinc and lead were found to be important contaminants in the sediments of the ditches of the swamp. Lead, copper, chromium, and selenium concentrations in water samples of the Great Dismal Swamp were found at elevated concentrations, which are also indicative of possible contamination. Since no baseline metal information is available for this region and there are no sediment criteria, these values may be within an acceptable range for this type of environment. Although no pesticides were detected in elevated concentrations, the detection of ephemeral compounds such as certain pesticides is virtually impossible.

Past surveys clearly indicate a possible metal contamination problem in the Great Dismal Swamp National Wildlife Refuge. Therefore a thorough baseline survey of contaminants in the swamp is recommended. Since the land use of the area surrounding the Refuge is predominately agricultural, storm water monitoring of run-off into the swamp is also suggested to detect any possible pesticide inputs. This is a major initiative both financially and in staff time. Since the baseline and storm water surveys are dependent on surface and groundwater flow patterns, these studies would be complemented by additional hydrogeologic information. Therefore, the final recommendation is to conduct a hydrogeologic survey of the Refuge, thereby identifying discharge and surface water flow patterns. Hydrologic data can then be correlated with baseline information of contaminant "hot spots." With this data, patterns of mobilization and pathways of contamination can then be more accurately assessed at the Refuge.

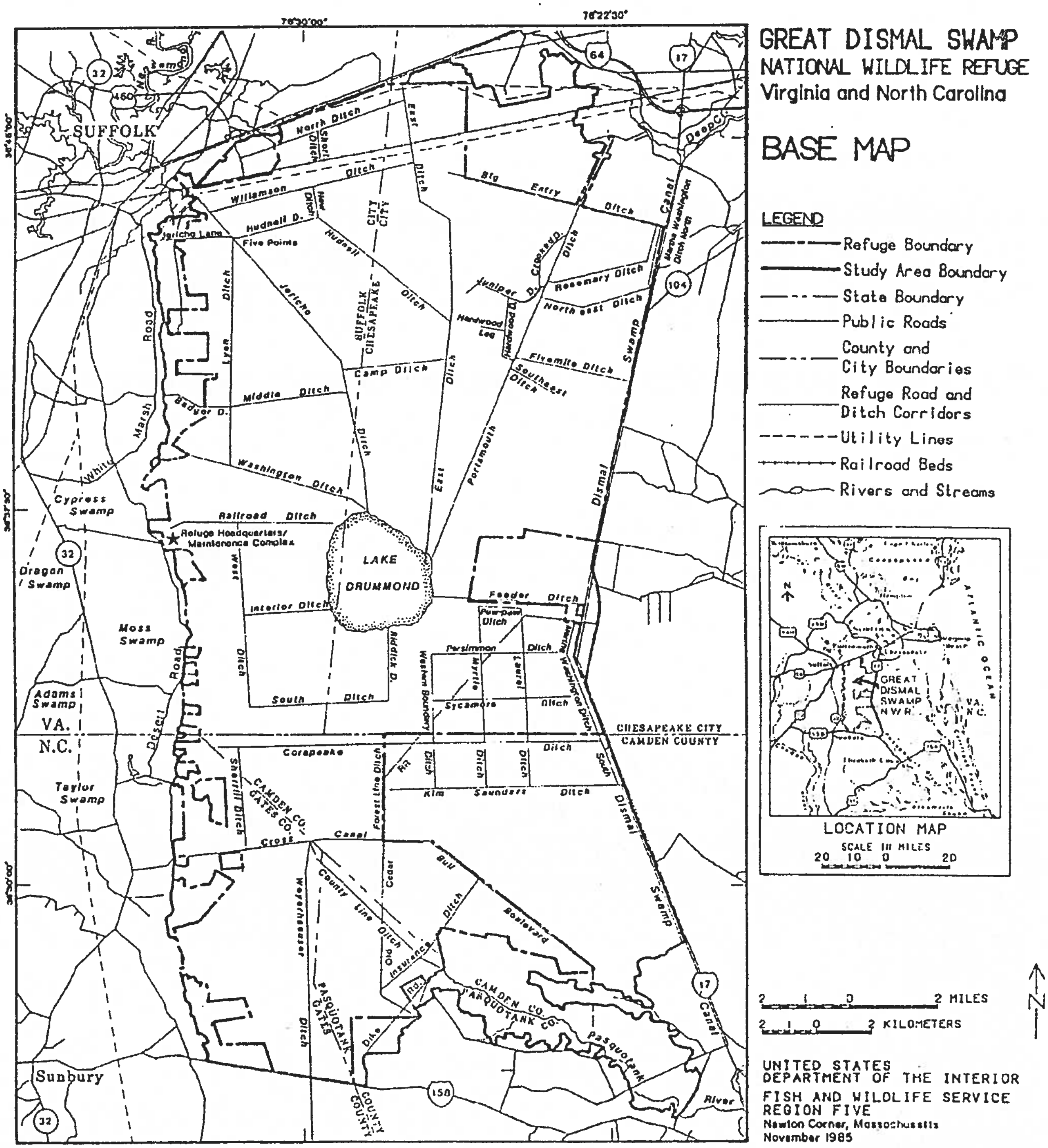
# The Great Dismal Swamp National Wildlife Refuge Contaminants Monitoring Plan

## Introduction

The Great Dismal Swamp National Wildlife Refuge (NWR), created through the Dismal Swamp Act of 1974 (Public Law 93-402), is located in the Cities of Chesapeake and Suffolk in Virginia, and Camden, Pasquotank and Gates Counties in North Carolina. The Refuge is about 433 square kilometers or 43,300 hectares in size (Carter, 1979), comprised mainly of palustrine forested wetlands with Lake Drummond, a 1,200 hectare shallow lake, in the central portion of the Refuge (Figure 1).

The natural drainage patterns of the Refuge have been changed dramatically by a series of ditches, which were cut in the 1700s and 1800s. These ditches were dug to facilitate logging of the forest, and to drain the swamp to produce fields for growing crops (Stewart, 1979). In the late 1700s, the larger Dismal Swamp Canal was begun on the eastern side of the swamp to facilitate commerce and transportation between Virginia and North Carolina. Due to financial constraints, the canal was not made large enough for the volume of commerce until a major reconstruction took place in the early 1800s. The large "Feeder Ditch" was also cut to connect Lake Drummond with the Dismal Swamp Canal. Although commercial use of the Dismal Swamp Canal later declined due to competition from the railroad, the canal is still in use today, mainly for recreational purposes (Stewart, 1979).

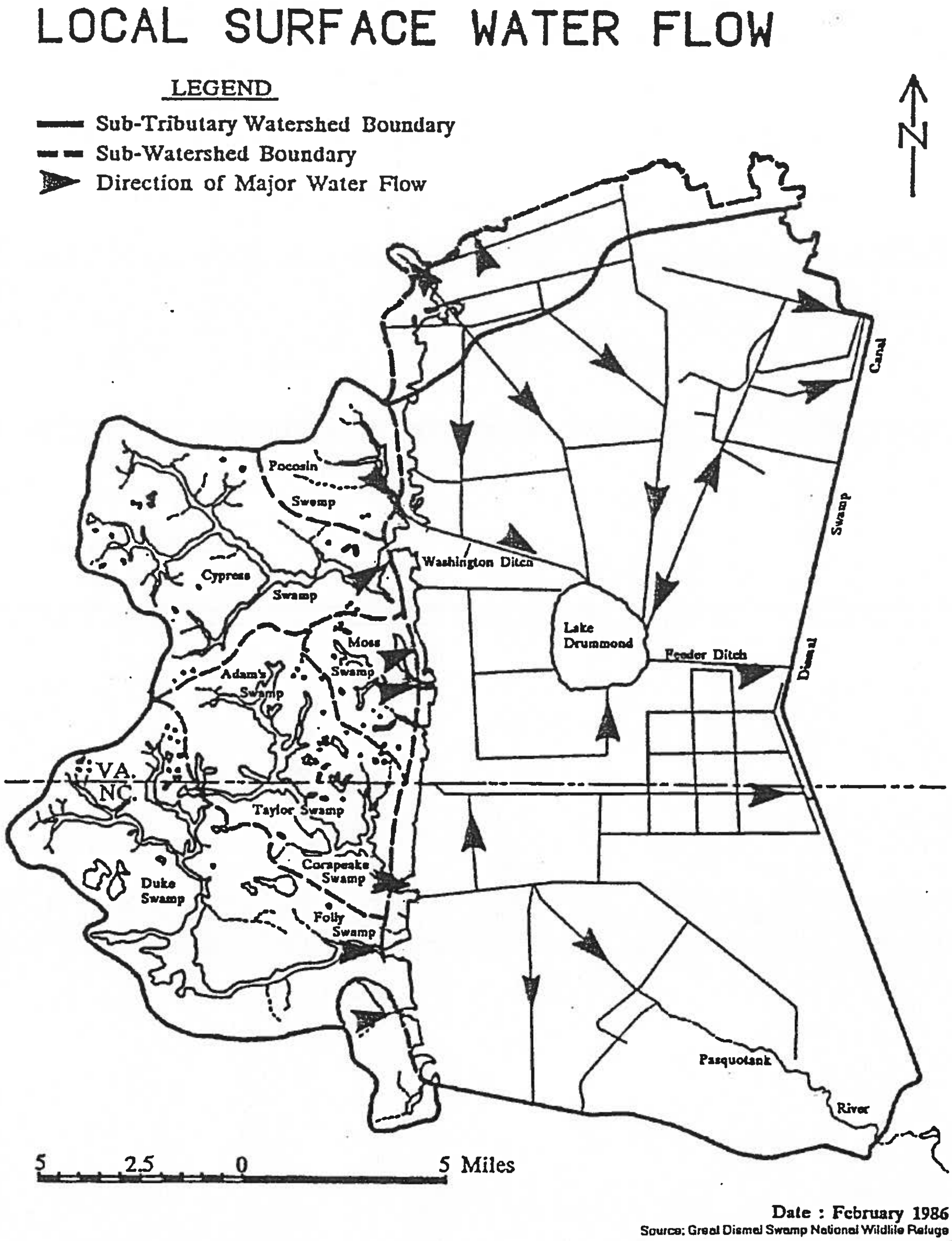
Figure 1. Map of the Great Dismal Swamp National Wildlife Refuge.



The hydrology of the Great Dismal Swamp in itself is a unique feature of the swamp. Lichtler and Walker (1979) summarized the hydrologic characteristics and determined general surface and groundwater flow patterns. Hydrologic flow is roughly diagramed in Figure 2. Groundwater predominately flows from the west from the Norfolk aquifer. Below the first few inches, the peat of the swamp is sapric indicating a poor water conductivity (Main, Inc., 1971). The bulk of the transport of water through the swamp occurs through the extensive ditch systems, through upward seepage into Lake Drummond, or through desiccation cracks in the peat (Lichtler and Walker 1979). Although the amount of groundwater discharged into the swamp has not been quantitatively measured, Lichtler and Walker (1979) report the amount of water involved is probably large. During dry seasons and other periods of low flow, ditches fill with groundwater (SCS Engineers, 1992). This phenomena is important since groundwater can continuously reintroduce contaminants, which can eventually contaminate surface waters and sediments.

Surface water flow throughout the Great Dismal Swamp is complex and additional study is necessary to fully understand the movement in this dynamic system. In 1991, the U.S. Geological Survey proposed an extensive study of the hydrology of the swamp (U.S. Geological Survey, 1991). This project was not funded, which is unfortunate given that additional hydrologic information would be useful for the adequate design of a contaminant monitoring plan. Lichtler and Walker (1979) reported that about 113 square miles of upland is a potential source for surface water runoff and inflow into the swamp, and this upland area could provide up to 31,000 million gallons of inflow per year. Only 13,100 million gallons of upland inflow enters Lake Drummond and 18,000

Figure 2. Flow patterns of the surface waters in the Great Dismal Swamp.



million gallons of runoff flow is intercepted by the ditch system in the southern section of the swamp (Main, Inc., 1971). The major outflow for surface water within the swamp is through ditches that funnel waters to Lake Drummond and then through the Feeder Ditch and to the Dismal Swamp Canal (Lichtler and Walker, 1979). Waters from Cross Canal flow into the Pasquotank River (Lichtler and Walker, 1979). The amount of outflow from the Great Dismal Swamp system depends heavily on the use of water control structures and precipitation. Flow within the swamp's ditches can actually be reversed from the traditional flow patterns by localized precipitation.

The environmental characteristics of the Swamp can alter the toxicity of some chemical compounds and should be considered in the development of any monitoring plan. Surface water in the swamp is naturally acidic, ranging from pH 3.0 to 6.0. The acidic nature of the surface water is a result of a leaching effect of organic acids from peat deposits in the swamp (Frey, 1949). Acidity plays an important role in the determination of the metal species made available in their toxic forms. Maximum acute toxicity is reported to occur at a slightly acid to neutral pH (Campbell and Stokes, 1985). Below this range, a trend of decreased toxicity is noted with decreasing pH. The upper pH values obtained in the Great Dismal Swamp are within the range that may promote the availability of many toxic metals to aquatic organisms. The activity of decomposer organisms is also decreased with pH values below 6, which leads to increased loads of organic matter into the swamp (Connell and Miller, 1984).

Surface waters in the Dismal Swamp have little buffering capacity, and are highly colored from humic substances and tannins. The toxicity and bioavailability of many metals and organic compounds is influenced by the organic makeup of the surface waters. The rates of adsorption and desorption of these compounds depends greatly upon the overall input of dissolved and suspended solids into the aquatic environment. The mobility of many metals is affected by complexation with other compounds such as organics and clay minerals (Faust and Aly, 1981).

Total hardness is defined as the sum of the calcium and magnesium concentrations both expressed as calcium carbonate ($CaCO_3$) in milligrams per liter (mg/L) (Clesceri et al., 1989). Total hardness has been reported to be between 15 to 30 mg/L (as $CaCO_3$) within Lake Drummond (Marshall, 1976) and between 10 and 80 mg/L (as $CaCO_3$) in the ditch systems (Stilwell, unpublished data). It has been found that hardness has a profound effect on the toxicity of metals to aquatic organisms. For example, rainbow trout exposed to similar concentrations of cadmium displayed a 60% mortality in waters with 20 mg/L hardness and yet only a 15% mortality in waters with a 320 mg/L hardness (Calamari et al., 1980). Since the hardness values reported for the waters of Lake Drummond and the supporting ditch systems have fairly low hardness concentrations, the protective value of hardness in relation to metal toxicity is not present in the Great Dismal Swamp surface waters.

According to the criteria established by the Virginia Water Control Board (VWCB) (1992), the waters of Lake Drummond are considered dystrophic and the waters that drain into the Lake are classified as water quality limited. Dystrophic waters are classified as having unusually high humic organic material and low planktonic productivity (VWCB, 1992). Turbidity is high in the surface waters of the swamp. Secchi disc readings range from 8 to 70 cm in Lake Drummond, although net collections for plankton yield detrital material as well as plankton (Marshall, 1979). Lake Drummond has a variety of phytoplankton forms; however diatoms and desmids dominate. The major forms of phytoplankton identified in Lake Drummond are *Asterionella formosa* and *Melosira granulata* (Marshall, 1976). Marshall (1976) also found the phytoplankton composition in the Feeder Ditch to be the same as that noted in Lake Drummond. Zooplankton studies indicate three categories dominate - cladocerans, copepods, and rotifers, with seasonal changes in the concentrations of the species noted (Marshall, 1979).

## Objectives

The Great Dismal Swamp National Wildlife Refuge Contaminants Monitoring Study was proposed as a detailed evaluation of the potential impacts of environmental contaminants to the resources of the Refuge. The goal of this study is to allow greater understanding of the processes and interactions involved with contaminants in the Great Dismal Swamp, resulting in a focused monitoring plan. The objectives of the study are as follows:

1. Obtain and analyze land use information, and existing water quality and other contaminants data to assess the potential contributions of nonpoint and point source discharges to the water quality of the Great Dismal Swamp.

2. Determine the natural resources that may be impacted by contaminants and how to effectively monitor for contaminants, taking into account the unique environmental characteristics of the Great Dismal Swamp.

3. Using the information obtained in the objectives above, develop a comprehensive contaminants monitoring plan for the Refuge.

4. Establish a communication network among Federal, State, and local government agencies, private conservation groups, and citizens to encourage them to participate in efforts to protect and enhance the water quality of the Great Dismal Swamp. Attempt to identify scientists and other conservation groups interested in a long-term monitoring project at the Great Dismal Swamp NWR.

## Resources Potentially Impacted by Contaminants

Few ecological studies have been conducted in the Great Dismal Swamp, and most have centered around Lake Drummond or involve the effects of the swamp environment on plant communities. The unique environment of the Great Dismal Swamp supports a wide variety of northern and southern plant species. The Great Dismal Swamp is the northern-most extreme for many southern species. The effect of fire, drainage, and logging has had a dominant role in the establishment of plant species, and the swamp is dominated by second-growth forests (Dean, 1969, Carter, 1988). Remote sensing, using infrared photographs from satellite systems, has located a small marsh community made up of grasses and aquatic emergent plants (cattails (Typha spp.), arrowheads (Sagitarria spp.), and sedges (Carex spp.)). This type of wetland community once dominated the swamp some 4000-8000 years ago (Carter, 1979).

A species of plant that is a candidate for Federal listing is present in the Great Dismal Swamp. The Virginia least trillium (Trillium pusillum Michx. var. virginianum) is sensitive to changes in the soil saturation and the effects of drainage in the swamp. In addition, the log fern (Dryopteris celsa), which is one of the rarest and most localized ferns in the eastern United States, is found in abundance in the Great Dismal Swamp (Wagner and Musselman, 1979).

Today, the bulk of the Swamp's vegetation is made up of dense stands of mature black gum (Nyssa sylvatica) and red maple (Acer rubrum) with ash (Fraxinus spp.) in hydric areas and sweet gum (Liquidambar styraciflua) in drier areas (Levy and Walker, 1979). The nature and the diversity of the environment in this mixed deciduous swamp and the associated ditch systems provide a wide variety of habitats for many fish and wildlife species.

There are approximately 27 species of fish inhabiting Lake Drummond and the Great Dismal Swamp ditches. Yellow bullhead (Ictalurus natalis) is the predominate species, but yellow perch (Perca flavescens), fliers (Centrarchus macropterus), and black crappie (Pomoxis nigromaculatus) are also present in large numbers. U.S. Fish and Wildlife Service fishery surveys in Lake Drummond indicate the average rate of growth in fish of the lake to be similar if not greater to that observed in other coastal Virginia lakes (Mayne et al., 1986). River herring (<u>Alosa</u> spp.) are anadromous fish that may utilize the Dismal Swamp Canal and the Pasquotank River system as a spawning and nursery areas (Johnson, 1985). Several species of fish sampled in a contaminants survey of the Great Dismal Swamp in 1987 showed elevated levels of metals (Ryan <u>et al</u>., 1992) (Table 1).

The subspecies <u>Sorex longirostris fisheri</u>, the Dismal Swamp southeastern shrew, is listed as a threatened species by the U.S. Fish and Wildlife Service, and is endemic only to the historic swamp. Therefore, any impacts to this small mammal is of special interest. The bald eagle (<u>Haliaeetus leucocephalus</u>) is listed as an endangered species by the U. S. Fish and Wildlife Service and may eat fish, birds, and small mammals utilizing the Refuge. The lake and ditches provide fishery resources for gulls, diving ducks, wading birds and recreational use. A listing of species that commonly inhabit the Great Dismal Swamp can be found in Appendix A.

## <u>Sources of Contamination and Land Use</u>

The Refuge is bordered on the west and north by several automobile junkyards, agricultural fields, and highways. Automobile junkyards and a major highway border the Refuge on the north, and are located adjacent to East Ditch, which flows directly into the Refuge. In February 1992, it was discovered that a junkyard operation was introducing contaminants into East Ditch. This ditch feeds its waters into Lake Drummond, therefore the potential to spread these contaminants throughout the Refuge exists. A contaminants survey of East Ditch sediments conducted in 1987 determined that some metals (arsenic, lead, copper, and zinc) and polycyclic aromatic hydrocarbons (PAH) (fluoranthene and phenanthrene) were elevated (Ryan et al., 1992). In order to establish if the junkyard was the source of these contaminants, additional sampling was conducted in 1992. Sediments from East Ditch adjacent to the junkyard displayed elevated levels of oil and grease (Table 2) and elevated levels of zinc and lead (Table 3). Water samples from this site did not indicate any significant concentrations of metals with the exception of iron (Table 4), which exceeded the Environmental Protection Agency (EPA) criteria of 1.0 mg/l for freshwater aquatic life. Although the operators of the junkyard have voluntarily initiated cleanup, runoff from these junkyards due to spilled or leaking fluids or unclean fill may continue to impact the Refuge.

Table 1. Metal concentrations in fish from Great Dismal Swamp National Wildlife Refuge, July 1987. Concentrations are in parts-per-million (dry-weight).

| SITE | ED | ED | BD | WD | WD | RR | LD | LD | LD | LD | LD | LD | LD | LD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | CCS | FL | FL | FL | GS | BSS | YBH1 | YBH2 | FL1 | FL2 | CP | YP1 | YP2 | BF |
| Compound | | | | | | | | | | | | | | |
| Se | 1.3 | 1.3 | 0.64 | 1.2 | 0.95 | 0.91 | 1.9 | 2.4 | 2.4 | 2.2 | 2.0 | 3.5 | 3.5 | 2.1 |
| As | 0.2 | 0.2 | 0.1 | 0.2 | 0.33 | 0.1 | ND | ND | 0.1 | ND | ND | ND | 0.1 | 0.2 |
| Hg | 0.083 | 0.170 | 0.675 | 1.4 | 2.1 | 1.1 | 0.815 | 0.573 | 0.604 | 0.567 | 4.3 | 2.6 | 2.5 | 3.2 |
| Ag | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Al | 386 | 28 | 8 | 62 | 332 | 49 | 170 | 78 | 5 | ND | ND | ND | ND | 5 |
| As | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| B | ND | ND | ND | ND | ND | 5.0 | ND | 6.5 | 6.3 | 5.0 | ND | ND | ND | ND |
| Ba | 10.5 | 3.8 | 11.2 | 13.3 | 24.3 | 6.4 | 27.8 | 26.0 | 13.3 | 15.3 | 3.5 | 5.7 | 4.4 | 3.1 |
| Be | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Cd | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Cr | 2.0 | 1.0 | 3.0 | 3.0 | 2.0 | 3.0 | 55.0 | 10.0 | 4.0 | 3.0 | 2.0 | 3.0 | 4.2 | 3.0 |
| Cu | 2.7 | 2.1 | 2.1 | 1.9 | 2.5 | 2.6 | 3.9 | 2.7 | 1.8 | 1.5 | 1.4 | 0.89 | 0.72 | 1.9 |
| Fe | 591 | 123 | 83 | 90 | 488 | 140 | 653 | 309 | 73 | 64 | 48 | 51 | 42 | 74 |
| Mg | 1940 | 2010 | 1720 | 1830 | 1650 | 1480 | 1610 | 1600 | 1950 | 2020 | 1700 | 1670 | 1600 | 2100 |
| Mn | 17 | 48 | 6 | 15 | 36 | 4 | 14 | 6 | 8 | 7 | 3 | 5 | 5 | 5 |
| Mo | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Ni | ND | ND | ND | ND | ND | ND | 26 | 4 | ND | ND | ND | ND | 7 | ND |
| Pb | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Se | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 5.0 | ND | ND |
| Sr | 115.0 | 127.0 | 123.0 | 150.0 | 98.2 | 97.8 | 178.0 | 185.0 | 205.0 | 220.0 | 46.6 | 119.0 | 106.0 | 34.0 |
| Tl | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| V | 0.6 | ND | ND | 0.4 | 0.7 | 1.2 | 1.5 | 1.3 | 0.3 | 0.3 | ND | 0.8 | 0.3 | 1.6 |
| Zn | 138.0 | 114.0 | 93.6 | 97.9 | 128.0 | 111.0 | 62.9 | 63.6 | 121.0 | 125.0 | 193.0 | 61.7 | 56.9 | 47.4 |

ND = below detection limit

SITES
ED = EAST DITCH
BD = BADGER DITCH
WD = WASHINGTON DITCH
RR = RAILROAD DITCH
LD = LAKE DRUMMOND

SPECIES
CCS = CREEK CHUBSUCKER
FL = FLIER
GS = GOLDEN SHINER
BSS = BLUE SPOTTED SUNFISH
YBH = YELLOW BULLHEAD
CP = CHAIN PICKEREL
YP = YELLOW PERCH
BF = BOWFIN

Source: Ryan et al., 1992

Table 2. Concentrations of oil and grease reported for East Ditch sediment samples, February 1992. Concentrations are expressed as parts-per-million.

| STATION | REPLICATE | OIL/GREASE |
|---|---|---|
| N | 1 | 1350 |
| N | 2 | 1260 |
| N | 3 | 1410 |
| RRN | 1 | 862 |
| RRN | 2 | 822 |
| RRN | 3 | 854 |
| RRS | 1 | 654 |
| RRS | 2 | 730 |
| RRS | 3 | 684 |

**STATION**

N = Northern most point of East Ditch (Junkyard Site)
RRN = East Ditch site north of railroad
RRS = East Ditch site south of railroad

Table 3. Metal Concentrations reported for East Ditch sediments, February 1992. Concentrations are expressed in parts-per-million, dry weight.

| Station | RRN | RRN | RRN | RRS | RRS | RRS | N | N | N |
|---|---|---|---|---|---|---|---|---|---|
| Rep # | A | B | C | A | B | C | A | B | C |
| METAL | | | | | | | | | |
| Al | 31700 | 30600 | 25300 | 30200 | 28000 | 26300 | 27500 | 22200 | 20100 |
| As | 10.2 | 9 | 4.3 | 7.4 | 12.5 | 11.1 | 19.1 | 25.5 | 23.9 |
| B | 2 | ND | 2 | ND | 3 | 2 | 7.2 | 13 | 15 |
| Ba | 144 | 144 | 124 | 159 | 151 | 152 | 86.3 | 106 | 105 |
| Be | 2.1 | 2.2 | 1.6 | 1.2 | 1.3 | 1.3 | 1.9 | 1.3 | 1.3 |
| Cd | 0.6 | 0.62 | 0.3 | 0.64 | 1.1 | 1 | 4.3 | 4.5 | 3.7 |
| Cr | 23 | 21 | 16 | 24 | 21 | 19 | 21 | 14 | 11 |
| Cu | 13 | 13 | 11 | 30 | 37.6 | 37.2 | 111 | 144 | 136 |
| Fe | 33600 | 32200 | 25800 | 20600 | 20900 | 19100 | 90500 | 132000 | 136000 |
| Hg | 0.13 | 0.12 | 0.11 | 0.08 | 0.099 | 0.07 | 0.2 | 0.35 | 0.29 |
| Mg | 1300 | 1240 | 1360 | 1290 | 1140 | 1110 | 1840 | 1800 | 1600 |
| Mn | 51.8 | 48.2 | 33.2 | 32.9 | 32 | 35.3 | 141 | 169 | 155 |
| Mo | 1 | ND | ND | ND | 1 | 1 | 2 | 3.4 | 3.2 |
| Ni | 19 | 18 | 15 | 13 | 15 | 16 | 29 | 25 | 25 |
| Pb | 45 | 43 | 30 | 46 | 53 | 55 | 250 | 280 | 270 |
| Se | 1.6 | 1.3 | 1.2 | 1.1 | 1.4 | 1.5 | 0.98 | 0.87 | 0.93 |
| Sr | 64 | 66.5 | 42.6 | 28.5 | 30.4 | 30.5 | 79.1 | 97 | 90.1 |
| V | 56.3 | 56.8 | 36.6 | 51.6 | 56 | 55.1 | 46.2 | 46.9 | 43.6 |
| Zn | 139 | 144 | 123 | 837 | 2090 | 396 | 845 | 718 | 703 |

ND = Not Detected

STATION

N = Northernmost point of East Ditch (Junkyard Site)
RRN = East Ditch, north of railroad
RRS = East Ditch, south of railroad

Table 4. Metal concentrations reported for East Ditch surface waters, February 1992. Concentrations are expressed in parts-per-million.

| Station # | RRN | RRN | RRN | RRS | RRS | RRS | N | N | N |
|---|---|---|---|---|---|---|---|---|---|
| Replicate # | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| METAL | | | | | | | | | |
| Al | 0.59 | 0.64 | 0.59 | 1.3 | 1.3 | 1.2 | 1.2 | 1.2 | 0.99 |
| As | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| B | 0.02 | 0.04 | 0.03 | 0.02 | 0.02 | ND | 0.28 | 0.28 | 0.25 |
| Ba | 0.026 | 0.027 | 0.026 | 0.042 | 0.042 | 0.041 | 0.064 | 0.06 | 0.062 |
| Be | ND | ND | ND | ND | 0.0001 | ND | 0.0002 | ND | ND |
| Cd | ND | ND | ND | ND | ND | ND | 0.0003 | ND | 0.0009 |
| Cr | 0.004 | 0.003 | 0.004 | ND | 0.003 | 0.005 | 0.005 | ND | ND |
| Cu | ND | ND | ND | ND | ND | ND | ND | 0.005 | ND |
| Fe | 1.3 | 1.4 | 1.4 | 0.27 | 0.23 | 0.25 | 4.5 | 3.6 | 2.8 |
| Hg | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Mg | 3.93 | 3.98 | 3.86 | 3.83 | 3.75 | 3.71 | 4.28 | 3.92 | 3.64 |
| Mn | 0.053 | 0.055 | 0.053 | 0.048 | 0.046 | 0.046 | 0.087 | 0.084 | 0.083 |
| Mo | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Ni | 0.003 | 0.006 | 0.003 | 0.003 | 0.003 | 0.004 | 0.011 | 0.006 | ND |
| Pb | ND | ND | 0.008 | ND | 0.005 | ND | 0.007 | ND | ND |
| Se | ND | ND | 0.002 | 0.017 | 0.003 | ND | ND | ND | 0.003 |
| Sr | 0.037 | 0.039 | 0.037 | 0.04 | 0.038 | 0.038 | 0.242 | 0.199 | 0.17 |
| V | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Zn | ND | ND | ND | 0.026 | 0.023 | 0.024 | 0.079 | 0.066 | 0.057 |

ND = Not Detected

<u>Stations</u>

N = northern most point of East Ditch (Junkyard Site)
RRN = East Ditch north of railroad
RRS = East Ditch south of railroad

In addition to the highway adjacent to the junkyard, a major widening project is proposed for U.S. Route 17, which runs the full length of the eastern border of the Refuge. Although the project is still in development, the impacts to the Refuge in regard to sediments loads and petroleum hydrocarbon inputs could be substantially increased from this action. A environmental impact statement will be prepared for this project by the Federal Highway Administration and the Virginia Department of Transportation and will then provide a more detailed estimation of potential threats to the surrounding environment. Selection of Refuge monitoring sites should include a representative location that might address the input from this highway project.

Two proposed projects involving landfills may impact the Refuge in the future. The present regional landfill of the Southern Public Service Authority is located along the northern border of the Great Dismal Swamp. No past contaminant surveys have indicated that this site is a source of toxic chemicals to the Refuge; however, contaminant loads may increase since there is a proposal to expand the landfill. Alternatives to the expansion of the existing landfill include the creation of a new landfill. One site proposed for the new landfill is located on the eastern border of the Refuge. This site would also pose a potential threat of introducing contaminants into the Refuge; although current surface water and groundwater flow patterns indicate the distribution would be minimal. However, the proposed new landfill site may alter groundwater flow by changing the hydrology of the area through digging of large borrow pits and thereby creating additional problems involving the mobilization of contaminants.

The area surrounding the Great Dismal Swamp is primarily devoted to agricultural uses. The City of Suffolk alone has over 70,000 acres of agricultural land (Slade, Extension Service, Suffolk, Virginia; pers. comm.). The primary crops grown in the area are peanuts and soybeans but corn, cotton, rye, and tobacco are also grown. According to the local extension agent, aldicarb is the major insecticide used in the region (Slade, Extension Service, Suffolk, Virginia; pers. comm.). Aldicarb is a carbamate pesticide and has a relatively low mammalian toxicity. Linuron, acifluorfen, and atrazine based herbicides are also extensively used in this area primarily during the spring and early summer (Slade, Extension Service, Suffolk, Virginia; pers. comm.). Atrazine is a heterocyclic nitrogen- based herbicide and many extension agencies have recommended a reduction in the use of this product (Ware, 1983). The input and movement of these and other pesticides into the environment depends on many variables including solubility of the compound, adsorption, bulk density, soil water content, and uptake by plants (Connell and Miller, 1984). The major sources of pesticides in the environment stem from aerial transport and deposition, and surface water runoff.

The Suffolk City Landfill Superfund Site was placed on the National Priorities List under the Comprehensive Environmental Response and Liability Act in 1989. This Superfund site is located is 1.5 miles upstream of the Refuge on the Pocosin Swamp, which drains into Washington Ditch and then to the Refuge. All waters draining the Superfund Site enter the Refuge. The landfill received industrial and domestic waste, as well as 30 tons of organophosphate pesticides that were buried on the site in the 1970s. Several steps were taken in order to contain and neutralize these pesticides and recent analyses for these compounds indicate they are no longer pose a concern (SCS Engineers, 1992). The major compound of concern in regard to the Suffolk City Landfill Superfund Site is arsenic. Arsenic levels were reported to be 11.4 micrograms per liter ($\mu g/l$) in surface waters and 71.9 $\mu g/l$ in groundwater during the remedial investigation for the site (SCS Engineers, 1992). Although there is no numerical national water quality criteria for arsenic, an effect concentration of 40 $\mu g/l$ was obtained for embyros and larvae of toads (U.S. EPA, 1985). Fish tissue samples from Washington Ditch, which drains the Pocosin Swamp, displayed a slightly elevated level of arsenic (330 $\mu g/l$) compared to the other sites sampled in the swamp (Ryan et al., 1992). Acute toxicity to freshwater organisms was reported at concentrations as low as 850 $\mu g/l$ (U.S. EPA, 1985). Although surface waters and sediments show relatively low levels of arsenic at the present time, the input of additional arsenic into the aquatic system through groundwater discharge and leachate runoff into the Great Dismal Swamp remains as a potential pathway of contamination.

The landfill, junkyards, agricultural fields, and highways may all pose threats to the biota in the swamp through contaminated surface runoff and through groundwater discharge. The cumulative impact of all potential contaminant inputs alone may warrant monitoring, although the transient nature of several of these inputs complicates the design of an adequate monitoring program. The bulk of the contaminants are being introduced into the aquatic system during storm events, causing distribution of agricultural chemicals, road run-off of petroleum products, and potential leachate inputs from the

Superfund Site to the swamp environment.

Contaminants of Concern

Surveys of contaminants in the surface waters of the Great Dismal Swamp have indicated some contaminant problems. Ryan et al. (1992) reported lead and copper levels in Hall Pocosin Swamp and copper concentrations in Pocosin Swamp exceeded EPA criteria (U.S. EPA, 1985). Railroad Ditch samples had elevated levels of selenium (50 $\mu$g/l). This value was similar to concentrations reported by Eisler (1985) in sewage contaminated waters. Chromium concentrations at Hall Pocosin Swamp (21 $\mu$g/l) and Pocosin Swamp (40 $\mu$g/l) were above the concentrations listed for freshwater lakes (Eisler, 1986). Iron levels found in Lake Drummond water samples (2.3 mg/l) exceeded criteria for freshwater aquatic organisms (1.0 mg/l) (VWCB, unpublished data). The increased metal concentrations may result from the natural leaching of these compounds from the soils and sediments by the acidic water of the swamp. In any case, there is evidence these compounds are accumulating in the aquatic biota of the swamp.

Sediment collected from East Ditch, Cypress Swamp, and Railroad Ditch tended to be higher in metals than other sampling sites in the swamp. Since there are no established criteria for sediment, it is difficult to fully evaluate sediment data. East Ditch sediment contaminant concentrations were above the Wisconsin Department of Natural Resources suggested sediment criteria for arsenic, lead, and zinc (Baudo et al., 1990). Copper concentrations (42 ppm) in East Ditch sediments were also within the range of concentrations (25-50 ppm) designated by the EPA as moderately polluted for Great Lakes sediments (Beyer, 1990). More intensive surveys of East Ditch conducted in 1992 indicated very high concentrations of arsenic (ranging 3.8 to 25.5 ppm), zinc (ranging 74.8 to 2090 ppm), and lead (ranging 30 to 280 ppm) (Table 2). These sediment concentrations are confirmed by the concentrations of metals observed in the water sampling.

Several surveys on contaminants in fish tissue have been conducted in the swamp. In January of 1984, a study was conducted by the U.S. Fish and Wildlife Service (Service) in order to determine if the level of contaminants in fish would be detrimental to other piscivorous wildlife. This study concluded that only mercury was of concern in chain pickerel (Swihart, unpublished report). This information was confirmed by a study conducted in 1987, which also found elevated levels of mercury in chain pickerel and yellow perch (Ryan et al., 1992). Mercury levels in fish collected from the Great Dismal Swamp were high in comparison to the national figures. Six stations from the 1984 study (ranged from 0.18 to 0.94 ppm) and three stations from the 1983 study (ranged from 0.20 to 1.1 ppm) displayed values that exceeded the 85th percentile (0.18 ppm) for mercury levels found in the National Contaminant Biomonitoring Program (NCBP) (Schmitt and Brumbaugh, 1990). A study conducted through the Albemarle Pamlico Estuarine Study (APES) also found elevated concentrations of mercury in chain pickerel and catfish (Cunningham et al., 1992). There could be a potential source of mercury contamination that is responsible for the elevated concentrations of mercury observed in these surveys of the Great Dismal Swamp. However, these increased levels of mercury in fish could also be due to bioaccumulation in top predators combined with the natural leaching of mercury from watershed soils by acidic waters.

Elevated levels of lead have also been reported in fish tissue samples collected from the Great Dismal Swamp. The APES study found lead concentrations in Corapeake Ditch chain pickerel (2.0 ppm) (Cunningham et al., 1992) that exceeded the national 85th percentile (0.22 ppm) of the NCBP (Schmitt and Brumbaugh, 1990). In 1984, the Service reported lead values of 1.2 ppm in yellow bullhead and 0.35 ppm in fliers (Ryan et al., 1992) which were above the NCBP's national 85th percentile of 0.22 ppm for lead (Schmitt and Brumbaugh, 1990).

Zinc concentrations in Dismal Swamp fish were found to be elevated in the APES and Service surveys. Corapeake Ditch chain pickerel (49.0 ppm) (Cunningham et al., 1992), Lake Drummond chain pickerel (66.6 ppm), and Washington Ditch redfin pickerel (51.8 ppm) (Swihart, unpublished data) all displayed concentrations above the 85th percentile of 34.2 ppm (Schmitt and Brumbaugh, 1990). This information was confirmed in several species analyzed in the 1987 survey conducted by the Service where zinc concentrations in fish ranged from 11.2 to 48.3 ppm (Ryan et al., 1992). It is difficult to assess whether these concentrations reflect a pollution source or whether the acidity of the waters has merely made more of these compounds available to the organisms analyzed.

## Organization Involvement

The development of information for this report resulted in the exchange of a important water quality and environmental contaminant data and information among government agencies and academic institutions. Several academic institutions expressed interest in either continuing and expanding their research in the Great Dismal Swamp or initiating research studies in the area. Old Dominion University has conducted extensive studies in regard to the plankton populations in Lake Drummond and expressed interest in expanding studies to include water quality issues. East Carolina University has conducted numerous studies of wetland areas similar to those found in the swamp and expressed interest in expanding the studies to include the Dismal Swamp. East Carolina University has also studied the metal distribution in the Pasquotank River and some of the wetland systems adjacent to the Great Dismal Swamp. The principal investigator (Dr. S. Riggs) for this North Carolina metal study expressed interest in surveying metals in the Great Dismal Swamp. Virginia Institute of Marine Science expressed interest in conducting a contaminants survey for the Great Dismal Swamp. These institutions currently have no funding to conduct these studies and expressed interest in participating in the U.S. Fish and Wildlife Service survey if funding was available.

Great Dismal Swamp National Wildlife Refuge personnel coordinate two groups of volunteers who would be available to collect samples for a contaminants monitoring survey. These volunteer groups, the Great Dismal Swamp Coalition and the Explorer Scouts (Great Dismal Swamp Unit), have participated in past Refuge activities and could provide support for this program. In addition, Refuge staff expressed willingness to provide personnel to conduct sample collections or supervise volunteers.

The Virginia Water Control Board (VWCB) currently conducts contaminant and water quality monitoring at one station in the Feeder Ditch on a consistent basis. This station's information is available through the STORET computer system. Several additional stations within the swamp's boundaries have been sampled for environmental contaminants on a sporadic basis and this material is also available on STORET. The Feeder Ditch station will continue to be monitored and this information has been requested. The VWCB maintains a database of information concerning state regulated industrial and municipal discharges in the Commonwealth of Virginia; however, at this time there are no regulated discharges in the Great Dismal Swamp area.

The North Carolina Department of Environmental Management (NCDEM) conducted some contaminant monitoring in Lake Drummond in 1983. No additional sampling has been conducted in the Great Dismal Swamp by NCDEM. The Albemarle-Pamlico Estuarine Study (APES) has conducted some surveys for contaminants in the Great Dismal Swamp area (Cunningham et al., 1992).

U.S. Geological Survey (USGS) supplied hydrologic information for the swamp. They also expressed continued interest in performing a more extensive survey of the hydrogeologic features of the Great Dismal Swamp.

## Monitoring Plan Alternatives

The environmental contaminants monitoring plan alternatives are outlined below. Specific protocols for each of the options within the proposed alternatives will be discussed in the next section of this document.

Budgetary requirements for each alternative are provided in Appendix B.

**Alternative 1:** No monitoring.

**Alternative 2:** Baseline survey, no long-term monitoring. Establish an accurate baseline monitoring study in which contaminant loads in the Great Dismal Swamp National Wildlife Refuge are assessed. Estimated Cost: <u>$ 58,000</u>

**Alternative 3:** Baseline survey, followed by annual contaminant monitoring of water and sediments. Information from the baseline survey used to select priority sampling locations for long-term monitoring. Estimated Cost: <u>$ 58,000 per year</u>

**Alternative 4:** Baseline survey and intensive short-term storm water monitoring. Estimated Cost: <u>$ 100,000</u>

**Alternative 5:** Hydrogeologic survey of groundwater discharge and surface water flow patterns followed by a baseline survey of contaminants. Estimated Cost: <u>$ 58,000 not including Hydrology Study</u>

## <u>Methods and Sampling Protocols</u>

**<u>Baseline Survey</u>:** A baseline survey would provide information regarding present concentrations of priority pollutants in the Great Dismal Swamp. Once a baseline is established, any significant alterations from the baseline can be used to determine if increased inputs of environmental contaminants are being introduced into the swamp over time. Sampling locations are mapped in Figure 3. These 11 sites were chosen based on drainage and flow of surface waters and groundwater. Many of these sites have also been used in past surveys. This allows for a consistency of information so eventually a database of environmental contaminants entering the swamp system can be established. The rationale for selecting each site is as follows:

Site 1 - East Ditch - East Ditch contained some of the highest metal concentrations of the entire Refuge in previous sampling. The junkyard adjacent to this site is still in operation; therefore this sampling location will continue to monitor the junkyard's input. This site is also near the active landfill.

Site 2 - Five Points - This site was recommended by Refuge personnel since it receives flow from 2 main drainage ditches and distributes the flow to 3 ditches. This site is also nearest to the City of Suffolk, the Superfund Site, and the active landfill.

Site 3 - Pocosin Swamp - This site has been previously sampled in a Service study. This site is also adjacent to the Superfund site.

Site 4 - Washington Ditch - This site has been previously sampled in a Service study. This is a major interception area for both Cypress and Pocosin Swamps.

Site 5 - Cypress Swamp - This site has been previously sampled in a Service study. Cypress Swamp drains a large portion of the eastern border of the swamp. Cypress Swamp has a USGS gauging station near this sampling location so relative inflow can estimated.

Site 6 - Hall Pocosin Swamp - This site has been previously sampled in a Service study and was found to have some of the larger contaminant loads of the study area. Hall Pocosin Swamp drains a large portion of the southeastern border of the swamp.

Site 7 - Pasquotank River - This site is a major drainage of the southern half of the swamp. The headwaters of the river originate in the Refuge.

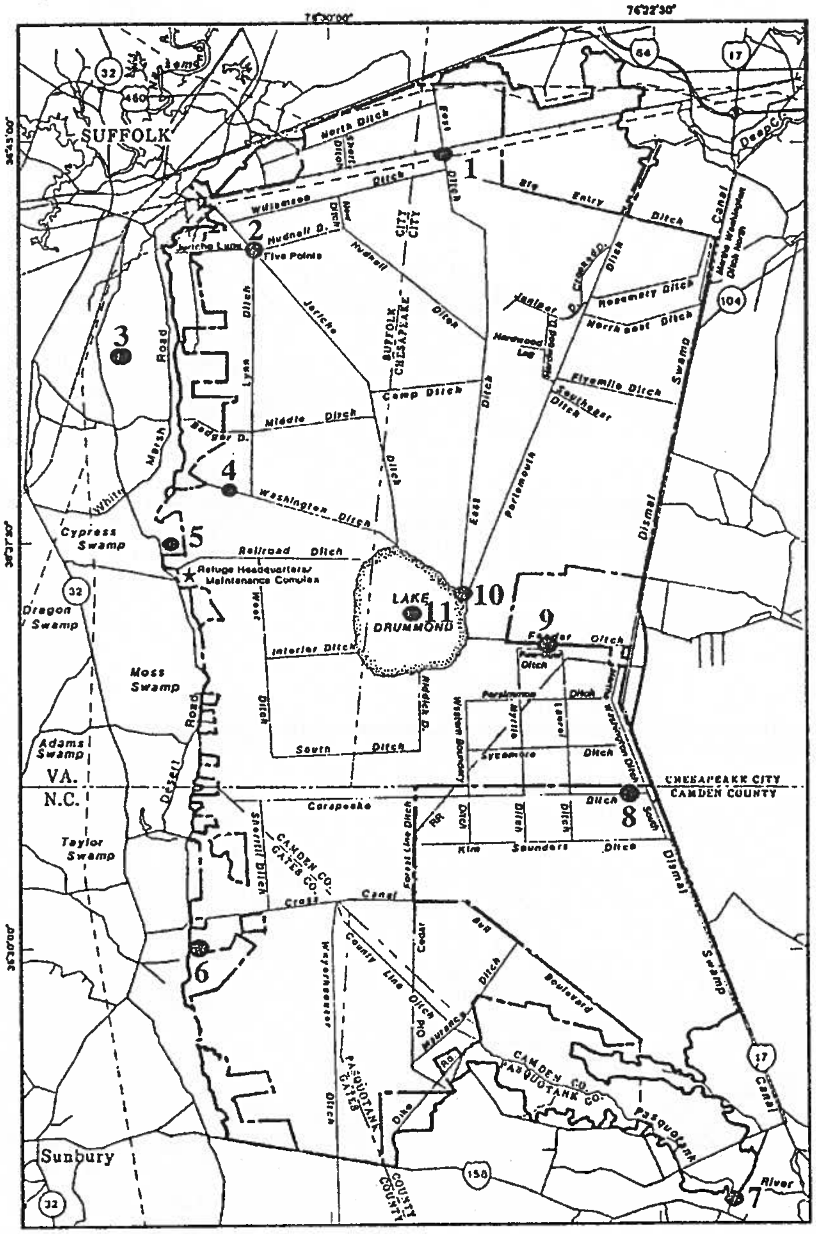
Site 8 - Corapeake Ditch - This site is a drainage of the mid and southern portion of the swamp. This site was sampled previously by an APES study.

Site 9 - Feeder Ditch - This site is continuously monitored by the VWCB. The Feeder Ditch is the major output for all swamp waters from the north and west in Virginia.

Site 10 - Portsmouth Ditch - This site has been previously sampled by both VWCB and Service studies. This site drains a portion of the northeastern portion of the swamp into Lake Drummond.

Site 11 - Lake Drummond - This site has been previously sampled by VWCB, Service, and APES studies. Surface waters are funneled into Lake Drummond from the ditch systems.

**Figure 3.** **Proposed Sampling Locations for Great Dismal Swamp National Wildlife Refuge Contaminant Monitoring Studies.**




| | |
|---|---|
| 1 = East Ditch | 2 = Five Corners |
| 3 = Pocosin Swamp | 4 = Washington Ditch |
| 5 = Cypress Swamp | 6 = Hall Pocosin Swamp |
| 7 = Pasquotank River | 8 = Corapeake Ditch |
| 9 = Feeder Ditch | 10 = Portsmouth Ditch |
| 11 = Lake Drummond | |

Sediment and water samples would be taken from each designated sampling location. All samples would be taken in triplicate so statistical analysis could be conducted. Analysis of sediment samples would consist of metal, polycyclic aromatic hydrocarbon (PAH) and organochlorine pesticide scans. Water samples would be analyzed for metals and organochlorine pesticides. Acid volatile sulfides and total organic carbon would also be analyzed in order to assess the availability of the metals. Sampling would be conducted in the late spring since the bulk of the pesticides are applied during this time and the surface waters would be at their highest levels. During sample collection, temperature, conductivity, hardness, turbidity, dissolved oxygen, nitrogen series, phosphorus series, and pH measurements would also be taken in the field.

<u>Annual monitoring</u>: The same sampling locations as those selected for the baseline survey would be used to conduct the yearly monitoring. Parameters and media to be analyzed in the baseline survey would also be used in the annual monitoring. Provisions for additional analysis or additional sampling sites should be anticipated given changes in the land use patterns for the surrounding areas. A database would be established to archive the yearly contaminant information and the data would be statistically analyzed for trends of increasing or decreasing contamination. After a five year period, all data would be evaluated and the need for additional sampling would then be determined.

<u>Storm water monitoring</u>: This program would be initiated after the baseline survey has been conducted. Sites that indicated possible pathways of

contamination through the baseline analysis would be selected for placement of automatic water samplers. The sampling of water would automatically be triggered by a storm event. Automatic samplers are programmed to initiate sampling when either rainfall exceeds a certain predetermined value or when flow rates exceed an established rate. Once the sampler is triggered, sampling continues at regular intervals for the duration of the storm event. This procedure allows for peak input over time to be sampled. Three storm events would be sampled quarterly for one year to assess the impacts of stormwater run-off.

**Hydrogeologic Survey**: Knowledge of the surface water flow dynamics and discharge patterns of groundwater of the Refuge has been identified as limiting factoring and critical aspect in the interpretation of contaminant data. Virginia Polytechnic University has expressed interest in conducting a hydrogeologic survey of the Refuge and is currently preparing a proposal outline. This survey would be coupled with the baseline contaminant survey.

## Conclusions and Recommendations

From the data obtained through past contaminant surveys, there does not appear to be a substantial environmental contaminant problem in the Great Dismal Swamp at the present time. However, increased industrialization and population trends in the region surrounding the Refuge indicate possible increases in contaminant inputs over time. It appears that the junkyards along the northern boundary of the Refuge may be the source of localized contaminant inputs, which should be further evaluated and remedied if necessary. The basic recommendation for contaminant monitoring for the Great Dismal Swamp National Wildlife Refuge would be to conduct a comprehensive baseline measurement of contaminants in the waters and sediments of the Refuge and adjacent areas (Alternative 2). As land use changes, periodic surveys of the same stations used in the baseline survey should be conducted in order to determine if substantial increases of contaminants have been introduced into the Refuge. At this point, yearly monitoring is not warranted, since past studies have shown similar concentrations of priority pollutants over a 5 year increment. Yearly sampling would only be indicated if a new source of contamination has been identified. Annual sampling, although adequate for determining if there is an increase of persistent chemical compounds into the swamp, will not detect transient, run-off related, or seasonal inputs into the Refuge.

Since the majority of the potential contaminant inputs into the Great Dismal Swamp National Wildlife Refuge are due to transient and run-off related pathways, Alterative 4 of this monitoring plan is suggested. Since Alterative 4 provides baseline information and storm water monitoring, the concentrations of contaminants present in the Great Dismal Swamp National Wildlife Refuge can be established and then followed by the information relating storm event inputs. Storm water monitoring would capture contaminants entering the Refuge which ordinarily would not be observed through traditional sampling methods. Run-off resulting from leachate from the Superfund site and the active landfill, road runoff, and agricultural inputs would all be characterized by this sampling regime. The drawback of this study is the cost, estimated to be approximately $100,000 for a comprehensive one and a half year study. The threat imposed from run-off associated compounds does not appear to be severe; however this conclusion can not be made without this additional sampling. Automatic water samplers have been purchased for an ongoing study at another refuge, Back Bay NWR. The Back Bay study of stormwater inputs will be initiated in FY 1993. That study will be a trial of the automatic sampling equipment and methods. Therefore, we recommend holding off the implementation a similar study at Great Dismal Swamp until the Back Bay study is complete.

The evaluation of contaminant input, mobilization, and availability would be best assessed by conducting a hydrogeologic study (Alternative 5). This aspect, coupled with a baseline contaminant survey would allow for a more comprehensive estimation of the impacts to the Refuge as a whole. Past contaminant surveys have simply provided information that identified contaminant "hot spots," without any information as to the extent of contamination or the potential for continued input into the Refuge. A hydrogeologic survey would provide valuable information that is necessary in order to conduct a thorough assessment of the contaminant problem in the Great Dismal Swamp.

The studies outlined in this report would be most effective if conducted as a multi-year initiative. Each study would provide a piece of crucial information necessary to make a conclusive determination of whether a contaminant problem at the Refuge exists. In year one, a hydrogeologic survey would provide information that would relate to contaminant input and movement. In year two, a baseline contaminant survey would provide information related to "hot spot" locations, and provide a statistically relevant database of contaminant concentrations. Finally, a short-term, comprehensive storm water monitoring survey would provide the information necessary to assess the input of ephemeral compounds into the Refuge. These three surveys could provide enough information to make a thorough and conclusion determination of contaminant problems at the Great Dismal Swamp.

In conclusion, the following are the Virginia Field Office's recommendations for the most appropriate method to assess contaminant inputs and impacts to the Great Dismal Swamp National Wildlife Refuge:

<u>Year One</u>: Conduct hydrogeological surveys. Exact cost is unknown, but could be in the range of $100,000 to $150,000.

<u>Year Two</u>: Conduct detailed baseline survey of sediments and surface waters at the 11 stations. Estimated cost: $ 58,000.

<u>Year Three</u>: Conduct intensive one-year study of stormwater inputs into the swamp. Estimated cost: $100,000.

It is assumed that the bulk of Virginia Field Office staff time as budgeted in Appendix B would be for data interpretation and logistical support on these contaminants studies. Data collection and processing (i.e. transportation, Hach Kit tests, and shipping) would be conducted by Refuge personnel or other designated volunteer groups. Cost associated with Refuge personnel salaries have not been included in these cost estimates.

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# Appendices

# Appendix A

## Species Commonly Found in the Great Dismal Swamp National Wildlife Refuge

## MAMMALS FOUND IN GREAT DISMAL SWAMP

Opossum (Didelphis marsupialis)
Dismal Swamp Southeastern Shrew (Sorex longirostris fisheri)
Dismal Swamp Short-tailed Shrew (Blarina telmalestes)
Least Shrew (Cryptotis parva)
Common Mole (Scalopus aquaticus)
Star-nosed Mole (Condylura cristata)
Keen Bat (Myotis keenii)
Pipistrelle (Pipistrellus subflavus)
Red Bat (Lasiurus borealis)
Evening Bat (Nycticeius humeralis)
LeConte's Big-eared Bat (Corynorhinus macrotis)
Cottontail (Sylvilagus floridanus)
Marsh Rabbit (Sylvilagus palustris)
Eastern Chipmunk (Tamias striatus)
Gray Squirrel (Sciurus carolinensis)
Southern Flying Squirrel (Glaucomys volans)
Rice Rat (Oryzomys palustris)
Harvest Mouse (Reithrodontomys humulis)
White-footed Mouse (Peromyscus leucopus)
Cotton Mouse (Peromyscus gossypinus)
Golden Mouse (Peromyscus nuttalli)
Lemming Mouse (Synaptomys cooperi)
Meadow Vole (Microtus pennsylvanicus)
Muskrat (Ondatra zibethicus)
Gray Fox (Urocyon cinereoargenteus)
Black Bear (Euarctos americanus)
Raccoon (Procyon lotor)
Longtail Weasel (Mustela frenata)
Mink (Mustela vison)
Otter (Lutra canadensis)
Bobcat (Lynx rufus)
White-tailed Deer (Odocoileus virginianus)

Source: Great Dismal Swamp National Wildlife Refuge, unpublished data.

## FISH SPECIES IN GREAT DISMAL SWAMP

Longnose Gar (*Lepisosteus ossens*)
Bowfin (*Amia calva*)
Redfin Pickerel (*Esox americanus*)
Chain Pickerel (*Esox niger*)
Golden Shiner (*Notemigonus crysoleucas*)
White Catfish (*Ictalurus catus*)
Channel Catfish (*Ictalurus punctatus*)
Yellow Bullhead (*Ictalurus natalis*)
Brown Bullhead (*Ictalurus nebulosus*)
American Eel (*Anguilla rostrata*)
Mosquitofish (*Gambusia affinis*)
Swampfish (*Chologaster cornuta*)
Pirate Perch (*Aphredoderus sayanus*)
Mud Sunfish (*Acantharchus pomotis*)
Flier (*Centrarchus macropterus*)
Warmouth (*Chaenobryttus gulosus*)
Blue Spotted Sunfish (*Enneacanthus gloriosus*)
Banded Sunfish (*Enneacanthus obesus*)
Redbreast Sunfish (*Lepomis auritus*)
Pumpkin Seed (*Lepomis gibbosus*)
Bluegill (*Lepomis macrochirus*)
Largemouth Bass (*Micropterus salmoides*)
Black Crappie (*Pomoxis nigremaculatus*)
Swamp Darter (*Etheostoma fusiforme*)
Yellow Perch (*Perca flavescens*)
Eastern Mudminnow (*Umbra pygmaea*)
Creek Chubsucker (*Erimyzon oblongus*)

Common, scientific, and family names are from Robins *et al*. 1991.

(Source: Great Dismal Swamp National Wildlife Refuge, unpublished data)

## DISMAL SWAMP BIRDS

Common Loon (Gavia immer)
Horned Grebe (Podiceps auritus)
Pied-billed Grebe (Podilymbus podiceps)
Double-crested Cormorant (Phalacrocofax auritus)
Anhinga (Anhinga anhinga)
Great Blue Heron (Ardea herodias)
Green Heron (Butorides virescens)
Little Blue Heron (Florida caerulea)
Cattle egret (Bubulcus ibis)
Common Egret (Casmerodius alabus)
Black-crowned Night Heron (Nycticorax nycticorax)
American Bittern (Botaurus lentiginosus)
Whistling Swan (Olor columbianus)
Canada Goose (Branta canadensis)
Mallard (Anas platyrhynchos)
Black Duck (Anas rubripes)
Pintail (Anas acuta)
Green-winged Teal (Anas crecca carolinensis)
Blue-winged Teal (Anas discors)
Wood Duck (Aix sponsa)
Ring-necked Duck (Aythya collaris)
Canvasback (Aythya valisineria)
Hooded Merganser (Lophodytes cucullatus)
Turkey Vulture (Cathartes aura)
Black Vulture (Coragyps atratus)
Sharp-shinned Hawk (Accipter striatus)
Cooper's Hawk (Accipter cooperii)
Red-tailed Hawk (Buteo jamaicensis)
Red-shouldered Hawk (Buteo lineatus)
Bald Eagle (Haliaeetus leucocephalus)
Marsh Hawk (Circus cyaneus)
Osprey (Pandion haliaetus)
Merlin (Falco columbarius)
American Kestrel (Falco sparverius)
Bobwhite (Colinus virginianus)
Turkey (Meleagris gallopavo)
King Rail (Rallus elegans)
Sora (Porzana carolina)
Common Gallinule (Gallinula chloropus)
American Coot (Fulica americana)
Killdeer (Charadrius vociferus)
American Woodcock (Philohela minor)
Common Snipe (Capella gallinago)
Whimbrel (Numenius phaeopus)
Spotted Sandpiper (Actitis macularia)
Solitary Sandpiper (Tringa solitaria)
Greater Yellowlegs (Tringa melanoleuca)
Semipalmated Sandpiper (Calidris pusilla)
Northern Phalarope (Lobipes lobatus)
Great Black-backed Gull (Larus marinus)
Herring Gull (Larus agentatus)
Ring-billed Gull (Larus delawarensis)

Laughing Gull (_Larus atricilla_)
Mourning Dove (_Zenaida macroura_)
Yellow-billed Cuckoo (_Coccyzus americanus_)
Black-billed Cuckoo (_Coccyzus erythropthalmus_)
Screech Owl (_Otus asio_)
Great Horned Owl (_Bubo virginianus_)
Barred Owl (_Strix varia_)
Chuck-will's-widow (_Caprimulgus carolinensis_)
Whip-poor-will (_Caprimulgus vociferus_)
Common Nighthawk (_Chordeiles minor_)
Chimney Swift (_Chaetura pelagica_)
Ruby-throated Hummingbird (_Archilochus colubris_)
Belted Kingfisher (_Megaceryle alcyon_)
Yellow-shafted Flicker (_Colaptes auratus_)
Pileated Woodpecker (_Dryocopus pileatus_)
Red-bellied Woodpecker (_Centurus carolinus_)
Red-headed Woodpecker (_Melanerpes erythrocephalus_)
Yellow-bellied Sapsucker (_Sphyrapicus varius_)
Hairy Woodpecker (_Dendrocopus villosus_)
Downy Woodpecker (_Dendrocopus pubescens_)
Red-cockaded Woodpecker (_Dendrocopus borealis_)
Eastern Kingbird (_Tyrannus tyrannus_)
Great Crested Flycatcher (_Myiarchus crinitus_)
Eastern Phoebe (_Sayornis phoebe_)
Acadian Flycatcher (_Empidonax virescens_)
Eastern Wood Pewee (_Contopus virens_)
Tree Swallow (_Iridoprocne bicolor_)
Rough-winged Swallow (_Stelgidoptery ruficollis_)
Barn Swallow (_Hirundo rustica_)
Purple Martin (_Progne subis_)
Blue Jay (_Cyanocitta cristata_)
Common Crow (_Corvus brachyrhynchos_)
Fish Crow (_Corvus ossifragus_)
Black-capped Chickadee (_Parus atricapillus_)
Carolina Chickadee (_Parus carolinensis_)
Tufted Titmouse (_Parus bicolor_)
White-breasted Nuthatch (_Sitta carolinensis_)
Red-breasted Nuthatch (_Sitta canadensis_)
Brown-headed Nuthatch (_Sitta pusilla_)
Brown Creeper (_Certhia familiaris_)
House Wren (_Troglodytes aedon_)
Winter Wren (_Troglodytes aedon_)
Carolina Wren (_Thryothorus ludovicianus_)
Mockingbird (_Mimus polyglottos_)
Gray Catbird (_Dumetella carolinensis_)
Brown Thrasher (_Toxostoma rufum_)
American Robin (_Turdus migratorius_)
Wood Thrush (_Hylocichla mustelina_)
Hermit Thrush (_Catharus gutlatus_)
Swainson's Thrush (_Catharus gutlatus_)
Gray-cheeked thrush (_Catharus minimus_)
Veery (_Catharus fuscescens_)
Eastern Bluebird (_Sialia sialis_)
Blue-gray Gnatcatcher (_Polioptila caerulea_)

Golden-crowned Kinglet (_Regulus satrapa_)
Ruby-crowned Kinglet (_Regulus calendula_)
Water Pipit (_Anthus spinoletta_)
Cedar Waxwing (_Bombycilla cedrorum_)
Loggerhead Shrike (_Lanius ludovicianus_)
Starling (_Sturnus vulgaris_)
White-eyed Vireo (_Vireo griseus_)
Yellow-throated Vireo (_Vireo flavifrons_)
Solitary Vireo (_Vireo solitarius_)
Red-eyed Vireo (_Vireo olivaceus_)
Warbling Vireo (_Vireo gilvus_)
Black-and-White Warbler (_Mniotilta varia_)
Prothonotary Warbler (_Protonotaria citrea_)
Swainson's Warbler (_Limnothlypis swainsonii_)
Worm-eating Warbler (_Helmitheros vermivorus_)
Golden-winged Warbler (_Vermivora chrysoptera_)
Blue-winged Warbler (_Vermivora pinus_)
Bachman's Warbler (_Vermivora bachmanii_)
Tennessee Warbler (_Vermivora peregrina_)
Nashville Warbler (_Vermivora ruficapilla_)
Parula Warbler (_Parula americana_)
Yellow Warbler (_Dendroica petchia_)
Magnolia Warbler (_Dendroica petchia_)
Black-throated Blue Warbler (_Dendroica caerulescens_)
Myrtle Warbler (_Dendroica coronata_)
Wayne's Warbler (_Dendroica coronata_)
Blackburnian Warbler (_Dendroica fusca_)
Yellow-throated Warbler (_Dendoica dominica_)
Chestnut-sided Warbler (_Dendroica pennsylvanica_)
Blackpoll Warbler (_Dendroica striata_)
Pine Warbler (_Dendroica pinus_)
Palm Warbler (_Dendroica palmarum_)
Ovenbird (_Seiurus aurocapillus_)
Northern Waterthrush (_Seiurus noveboracensis_)
Louisiana Waterthrush (_Seiurus noveboracensis_)
Kentucky Warbler (_Oporonis formosus_)
Yellowthroat (_Geothlypis trichas_)
Yellow-breasted Chat (_Icteria virens_)
Hooded Warbler (_Wilsonia citrina_)
Wilson's Warbler (_Wilsonia pusilla_)
Canada Warbler (_Wilsonia canadensis_)
American Redstart (_Setophaga ruticilla_)
Bobolink (_Dolichonyx oryzivorus_)
Red-winged Blackbird (_Agelaius phoeniceus_)
Orchard Oriole (_Icterus spurius_)
Baltimore Oriole (_Icterus galbula galbula_)
Rusty Blackbird (_Euphagus carolinus_)
Brewer's Blackbird (_Euphagus cyanocephalus_)
Common Grackle (_Quiscalus quiscula_)
Brown-headed Cowbird (_Molothrus ater_)
Scarlet Tanger (_Piranga olivacea_)
Summer Tanager (_Piranga rubra_)
Cardinal (_Richmondena cardinalis_)
Rose-breasted Grosbeak (_Guiraca caerulea_)

Blue Grosbeak (Guiraca caerulea)
Indigo Bunting (Passerina cyanea)
Evening Grosbeak (Hesperiphona vespertina)
Purple Finch (Carpodacus purpureus)
Pine Siskin (Spinus pinus)
American Goldfinch (Spinus tristis)
Red Crossbill (Loxia curvirostra)
Rufous-sided Towhee (Pipilo erythropthalmus)
Dark-eyed Junco (Junco hyemalis)
Tree Sparrow (Spizella arborea)
Chipping Sparrow (Spizella Passerina)
Field Sparrow (Spizella pusilla)
White-crowned Sparrow (Zonotrichia leucophrys)
White-throated Sparrow (Zonotrichia albicollis)
Fox Sparrow (Passerella iliaca)
Swamp Sparrow (Melospiza georgiana)
Song Sparrow (Melospiza melodia)

Source: Meanley, B. 1979. An analysis of the birdlife of the Dismal Swamp. In: Kirk, P.W., Jr. Ed. The Great Dismal Swamp. University Press of Virginia. Charlottesville, Virginia. pp. 260-276.

## AMPHIBIANS AND REPTILES

Eastern spadefoot toad (Scaphiopus holbrooki holbrooki)
Amercian toad (Bufo americanus americanus Holbrook)
Southern toad (Bufo terrestris Bonnaterre)
Fowler's toad (Bufo woodhousii fowleri Hinckley)
Oak toad (Bufo quercicus Holbrook)
Spring peeper (Hyla crucifer crucifer Wied)
Green treefrog (Hyla cinerea cinerea Schneider)
Pinewoods treefrog (Hyla femoralis Latreille)
Squirrel treefrog (Hyla squirrella Sonnini and Latreille)
Gray treefrog (Hyla versicolor versicolor Le Conte)
Little grass frog (Limnaodus ocularis Holbrook)
Upland chorus frog (Pseudacris triseriata feriarum Baird)
Brimley's chorus frog (Pseudacris brimleyi Brandt and Walker)
Southern cricket frog (Acris gryllus gryllus Le Conte)
Bullfrog (Rana catesbeiana Shaw)
Carpenter frog (Rana virgatipes Cope)
Green frog (Rana clamitans melanota Rafinesque)
Southern leopard frog (Rana utricularia Harlan)
Eastern narrow-mouthed toad (Gastrophyrne carolinensis Holbrook)
Greater siren (Siren lacertina L.)
Dwarf waterdog (Necturus punctatus punctatus Gibbes)
Two-toed amphiuma (Amphiuma means means Garden)
Marbled salamander (Ambystoma opacum Gravenhorst)
Southern dusky salamander (Desmognathus fuscus auriculatus Holbrook)
Red-backed salamander (Plethodon cinercus cinercus Green)
Slimy salamander (Plethodon glutinosis glutinosis Green)
Many-lined salamander (Sterochilus marginatus Hallowell)
Southern two-lined salamander (Eurycea bislineata cirrigera Green)
Common snapping turtle (Chelydra serpentina serpentina L.)
Stinkpot (Sternothaerus odoratus Latreille)
Eastern mud turtle (Kinosternon subrubrum subrubrum Lacepede)
Spotted turtle (Clemmys guttata Schneider)
Eastern box turtle (Terrepene carolina carolina L.)
Eastern painted turtle (Chrysemys scripta scripta Schoepff)
River cooter (Chrysemys concinna concinna Le Conte)
Green anole (Anolis carolinensis carolinensis Voigt)
Northern fence lizard (Sceloporous undulatus hyacinthinus Green)
Ground skink (Lygosoma laterale Say)
Five-lined skink (Eumeces fasciatus L.)
Broad-headed skink (Eumeces laticeps Schneider)
Southeastern five-lined skink (Eumeces inexpectatus Taylor)
Eastern glass lizard (Ophisaurus ventralis L.)
Eastern slender glass lizard (Ophisaurus attenatus longicaudus McConkey)
Brown water snake (Natrix taxispilota Holbrook)
Red-bellied water snake (Natrix erythrogastor erythrogastor Forster)
Northern water snake (Natrix sipedon sipedon L.)
Glossy water snake (Natrix rigida Say)
Northern brown snake (Storeria dekayi dekayi Holbrook)
Northern red-bellied snake (Storeria occipitomaculata occipitomaculata Storer)
Eastern ribbon snake (Thamnophis sauritus sauritus L.)
Eastern garter snake (Thamnophis sirtalis sirtalis L.)

Eastern earth snake (Virginia valeriae valeriae Baird and Girard)
Eastern hognose snake (Heterodon platyrhinos platyrhinos Latreille)
Southern ringneck snake (Diadophis punctatus punctatus L.)
Eastern worm snake (Carphophis amoenus amoenus Say)
Rainbow snake (Farancia erythrgramma erythrogramma Palisot de Beauvois)
Eastern mud snake (Farancia abacura abacura Holbrook)
Northern black racer (Coluber constrictor constrictor L.)
Rough green snake (Opheodrys aestivus L.)
Black rat snake (Elaphe obsoleta obsoleta Say)
Eastern kingsnake (Lampropeltis getulus getulus L.)
Scarlet kingsnake (Lampropeltis triangulum elapsoides Holbrook)
Southern copperhead (Agkistrodon contortrix contortrix L.)
Eastern cottonmouth (Agkistrodon piscivorus piscivorus Lacepede)
Canebrake rattlesnake (Crotalus horridus atricaudatus Latreille)

Source: Delzell, D.E. 1979. A provisional checklist of amphibians and reptiles in the Dismal Swamp area, with comments on their range of distribution. In: Kirk, P.W., Jr. Ed. The Great Dismal Swamp. University Press of Virginia. Charlottesville, Virginia. pp. 244-260.

## Appendix B

## Budgets for Alternative Contaminant Monitoring Plans for the Great Dismal Swamp National Wildlife Refuge

## Budget for Alternatives

### Alternative 1 - No monitoring

There are no costs associated with this alternative

### Alternative 2 - Baseline Survey (FY 95/96)

I. Operational Cost Estimates

| | |
|---|---|
| A. Supplies | |
| Hach Kit Reagents | $ 3,200 |
| Miscellaneous (shipping, boat and vehicle supplies, telephone, copying, etc. | 600 |
| B. Salaries | |
| GS-11 Biologist - 5 staff days | 620 |
| GS-9 Biologist - 10 staff days | 1,300 |
| GS-5 Bio-Tech - 15 staff days | 1,250 |
| Total Operational Costs | $ 6,700 |
| II. Analytical Cost Estimates | $ 44,500 |
| TOTALS | $ 58,000 |

### Alternative 3 - Baseline (FY 95/96) and Yearly Monitoring

I. Operational Cost Estimates

| | |
|---|---|
| A. Supplies | |
| Hach Kit Reagents | $ 3,200 |
| Miscellaneous (shipping, boat and vehicle supplies, telephone, copying, etc. | 600 |
| B. Salaries | |
| GS-11 Biologist - 5 staff days | 620 |
| GS-9 Biologist - 10 staff days | 1,300 |
| GS-5 Bio-Tech - 15 staff days | 1,250 |
| Total Operational Costs | $ 6,700 |
| II. Analytical Cost Estimates | $ 44,500 |
| TOTALS | $ 58,000* |

* At least this cost would be incurred during each fiscal year for the duration of the monitoring program. Actual costs would rise each year based on inflation and salary increases.

**<u>Alternative 4</u> - Baseline Survey (FY 95/96) and Storm Water Monitoring (FY 96/97)**

I. <u>Operational Cost Estimates</u>

| | |
|---|---|
| A. Supplies and Equipment | |
| Hach Kit Reagents | $ 3,200 |
| Automatic Water Samplers | |
| Base Units (5)* | 26,000 |
| Stormwater feature | 1,300 |
| Data transfer unit | 500 |
| Software | 610 |
| Spare batteries | 960 |
| Tipping rain gauge | 3,380 |
| Extra sampling bottles | 500 |
| Building Supplies (for water samplers) | 1,000 |
| Miscellaneous (shipping, boat and vehicle supplies, telephone, copying, etc. | 600 |
| B. Salaries | |
| GS-12 Supervisor - 5 staff days | 1,100 |
| GS-11 Biologist - 10 staff days | 1,300 |
| GS-9 Biologist - 40 staff days | 5,000 |
| GS-5 Bio-Tech - 50 staff days | 4,000 |
| Total Operational Costs | $ 46,300 |
| II. <u>Analytical Cost Estimates</u> | $ 53,000 |
| TOTALS | $ 100,000 |

* Assumes the seven automatic samplers purchased for the Back Bay Stormawater Study could be transferred to the Great Dismal Swamp Study.

**Alternative 5** - **Hydrogeologic Survey and Baseline Survey (FY 95/96)**

| | |
|---|---|
| I. Operational Cost Estimates | |
| A. Supplies and Equipment | |
| Hach Kit Reagents | $ 3,200 |
| Hach Water Quality Kit | 3,000 |
| Miscellaneous (shipping, boat and vehicle supplies, telephone, copying, etc. | 600 |
| B. Salaries | |
| GS-12 Supervisor - 5 staff days | 1,100 |
| GS-11 Biologist - 10 staff days | 1,300 |
| GS-9 Biologist - 20 staff days | 2,500 |
| GS-5 Bio-Tech - 15 staff days | 1,250 |
| Total Operational Costs | $ 13,000 |
| II. Analytical Cost Estimates | $ 44,500 |
| TOTALS | $ 58,000* |

* These costs do not include the costs involved in the hydrogeologic survey. These costs only cover the Service's participation and oversight. Hydrogeologic survey costs will be submitted through the proposals prepared by Virginia Polytechnic University.

# APPENDIX C

## COMPOUNDS TO BE ANALYZED

## METALS

Aluminum (Al)
Arsenic (As)
Antimony (Sb)
Barium (Ba)
Beryllium (Be)
Boron (B)
Cadmium (Cd)
Chromium (Cr)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Magnesium (Mg)
Manganese (Mn)
Mercury (Hg)
Molybdenum (Mo)
Nickel (Ni)
Selenium (Se)
Silver (Ag)
Strontium (Sr)
Thallium (Tl)
Tin (Sn)
Vanadium (V)
Zinc (Zn)

## Organochlorine Compounds

HCB (Hexachlorobenzene)
α-BHC (benzene hexachloride)
Γ-BHC (benzene hexachloride)
-BHC (benzene hexachloride)
δ-BHC (benzene hexachloride)
Oxychlordane
Heptachlor
Heptachlor Epoxide
Methoxychlor
c-Chlordane
t-Nonachlor
Toxaphene
PCBs (Polychlorinated biphenyls (total))
o, p'-DDE (dichlorodiphenyldichloroethylene)
t-Chlordane
p, p'-DDE (dichlorodiphenyldichloroethylene)
Dieldrin
Aldrin
o, p'-DDD (1,1-dichloro-2,2-bis(p-chlorophenyl) ethanex)
Endrin
c-nonachlor
o, p'-DDT (dichlorodiphenyltrichloroethane)
p, p'-DDD (1,1-dichloro-2,2-bis(p-chlorophenyl) ethanex)
p, p'-DDT (dichlorodiphenyltrichloroethane)
Mirex
Endosulfan I
Endosulfan II
Endosulfan sulfate
DCPA (Dimethyl tetrachloroterephthalate)
Dicofol
Tetradifon

## Polyaromatic Hydrocarbons

Naphthalene
Acenaphthylene
Acenaphthene
Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benzo(a)anthracene
Chrysene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Benzo(e)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenz(ah)anthracene
Benzo(ghi)perylene

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